A-96-47
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 30 2002

OFFICE OF
RESEARCH AND DEVELOPMENT

Memorandum

Subject: Method for Approximate ("Top Down") Estimate of Aggregate Cancer Risk Associated with Two Maximum Achievable Control Technology (MACT) Source Categories: Reciprocating Internal Combustion Engines (RICE) and Industrial/Commercial/Institutional Boilers

NOV 22 2002
EPA AIR DOCKET

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To: Rulemaking Docket

The purpose of this memorandum is to describe the methods used to estimate aggregate (incidence) inhalation cancer risk associated with proposed MACT standards from hazardous air pollutants (HAPs) emitted by two source categories, Institutional Boilers and Reciprocating Internal Combustion Engines (RICE). These methods do not address any potential inhalation non-cancer effects, nor do they address any potential ingestion risks associated with deposition of HAPs and resultant food contamination. Further, the methods used here are only useful to examine relative risk in a very approximate manner, and have not been peer reviewed by scientists outside the Agency. The purpose of this assessment it to help EPA meet the requirement to perform cost-benefit analyses as required for major regulations under Executive Order 12866. While this memorandum presents two approaches to estimate these risks, these should not be regarded as "bounding" true risk in any way; the true cancer risk associated with these source categories is unknown.

Step 1

To begin this analysis, we need to determine the percentage of overall mortality associated with air pollution. Relying on Table 3 of Murray and Lopez (1999), we used the estimate of 0.9% of total deaths associated with air pollution in "Established Market Economies."

Step 2a

The above value includes cancer-related deaths as well as deaths from other causes associated with air pollution, most notably cardiopulmonary deaths related to exposure to criteria pollutants. To disentangle this, we relied upon Table 2 of the Hollander *et al.* (1999) paper. That table shows the number of deaths in the Netherlands that have been calculated to be linked with particular air pollutant/endpoint combinations. Based on the estimates from this paper, about 2% of air pollution deaths are attributable cancer.

We multiplied the percentage of deaths associated with air pollution (0.9%) with the number of these associated with air toxics/cancer (2%), and multiplied this product by the 2.4 million deaths in the US annually (from National Center for Health Statistics (NCHS) data) to arrive at an estimate of roughly 500 deaths associated with inhalation cancer risk from outdoor air toxics.

Step 2.b

As an alternative approach to that above, we have used a second set of assumptions for deriving an estimate of deaths associated with cancer risk from outdoor air as follows:

As above we assume that 0.9% of total cancers are from air pollution, but rather than relying on the Hollander *et al.* estimates, we assume that about a quarter (23%) of mortality results from cancer, a figure based on NCHS statistics. Using the 2.4 million total deaths, this results in an estimate about 5,000 deaths associated with inhalation cancer risk from outdoor air toxics.

Step 3

Next, we need to estimate the risk associated with the emissions reductions associated with the specific MACT standards. To do this, we first identified the full set of air toxics emissions that would account for the 500 or so cancer deaths (or 5,000 in the alternative approach) nationwide. We used the national air toxics inventory (as presented at the NATA web site) to define these emissions. Taking from the list only those pollutants that are potential carcinogens, we then took the expected pollutant reductions and took the ratio of reductions to the total emissions. We multiplied this ratio by the 500 (5,000) air toxic deaths to derive a mortality risk estimate for these source categories. Once this is done, we estimate about 4 cancer deaths to be prevented annually for RICE, 0.4 deaths for boilers for the first approach, and about an order of magnitude higher (40, 4) for the second.

Step 4

Finally, to estimate cancer incidence (cases) rather than cancer deaths, we simply doubled these estimates to approximate cancer incidence. This is taken from Surveillance, Epidemiology, and End Results (SEER) and NCHS data, which indicate that there were about half as many cancer deaths as new diagnoses these days.

Uncertainties/Limitations/Bias

There are huge uncertainties and limitations that we expect are self-evident in a broad analysis such as this. In this section we highlight the major areas of sources of uncertainty and potential bias for each step of the analysis.

1. For the first step, it is reasonable that the actual percentage of total deaths in the U.S. associated with air pollution is within an order of magnitude of this estimate for "established market economies"; such an estimate is roughly in line with other estimates.

2. In step 2, we believe that the actual percentage of total cancer deaths associated with inhalation of air toxics as a percentage of deaths from air pollution in the U.S. is a bit harder to ferret out. With respect to the estimate derived from Hollander *et al.*, one source of uncertainty is the fact that the Netherlands is different from the U.S. with respect to a number of factors, *e.g.*, degree of industrialization, population density. In addition, it is clear from the paper that there is a differential coverage of pollutants (relative to the national emission inventory used for NATA), leading to a possible underestimate of relative risk.

The alternative approach assumes that the well-established causes of death in the general US population are the same as for those deaths related to air pollution. While this appears to be an unbiased estimate, in the absence of more detail on the derivation of air pollution mortality risk estimates in the Murray and Lopez paper it is difficult to say where the bias is. However, in the broader literature on air pollution mortality, the preponderance of cardiovascular mortality from criteria air pollutants would lead one to the view that this approach likely overstates the air toxic/cancer component.

3. In step 3, there are many uncertainties. First, there is considerable methodological uncertainty inherent in considering emissions data in the absence of considering exposure to estimate risk. To the extent that the nature of the individual pollutants and their sources influences exposure differentially, this will distort the analysis. Second, there are uncertainties in the emissions estimates themselves used, both in the national inventory and specific to these MACT standards. Third, and perhaps most importantly, there is considerable uncertainty in using total carcinogenic emissions without weighting them as to potency or weight of evidence. Setting aside the weight of evidence issue, an inspection of the specific pollutants controlled by these standards would lead one to conclude that ignoring potency would tend to (relatively) overstate risk for RICE (*i.e.*, the pollutants controlled tend to be less potent than average) and understate risk for boilers (where the converse is true).

4. Because it is unclear whether air pollution induced cancer are more or less lethal than other cancers, there is uncertainty about the assumption that the mix of cancers (in terms of lethality) from air toxics is similar to that in the general population. However, given that the statistics we used here do not include non-melanoma skin cancers (a common non-lethal cancer not typically related to air pollution), this effect may not be significant.

References

Christopher J.L. Murray and Alan Lopez "On the Comparable Quantification of Health Risks Lessons from the Global Burden of Disease Study, " Epidemiology, September,1999, Vol. 10 No. 5.

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Surveillance, Epidemiology, and End Results, "Supplemental Materials #1: Rates and Trends for the Top 15 Cancer Sites By Sex and Race/Ethnicity for 1992-1998," available at: http://seer.cancer.gov/Publications/ReportCard/OtherSupplem/Top15i.pdf; 2001.

4. National Center for Health Statistics, "Table 310, Deaths by Single Years of Age, Sex and Race, United States, 1999," available at: http://www.cdc.gov/nchs/datawh/statab/unpubd/mortabs/gmwk310_10.htm, 2001

	Deaths	Cancer Deaths	Percentage	Dealths/Incidence
1999	2,391,399	549,838	23.0%	48%
2000	2,404,598	551,833	22.9%	49%
	(NCHS)	(SEER)		

1998 Age adjusted cancer incidence rate per 100000)	*US population*	*US Pop / 100000*	*Incidence in US (1998)*
397.8	286,000,000	2,860.00	1,137,708.00
(SEER)	(Census)		

Air pollution mortality
(from Hollander et al, 1997)

	Total	*Cancer*	
PM	15597	439	
PM (S/I)	1114	0	
Ozone	3840	0	
PAH	17	17	
Benzene	5.3	5.6	
EtO	0.1	0.1	
VC	0.8	0.8	
1,2-DCE	0.1	0.1	
Acryl	0.1	0.1	
Total	20574.4	462.4	2.25%

485.4498795
This is taking .9% of deaths to AP, 2.25% is cancer, 2400000 deaths
4948.542
This is taking .9% of deaths to AP, 23% is cancer, 2400000 deaths

(NATA)

Pollutant	Nationwide emissions	Reducions for RICE	Reductions for Boilers
Acetaldehyde	9.72E+04	1033	
Acrolein	2.90E+04	922	
Acrylonitrile	1.26E+03		
As	3.95E+02		56.6
Benzene	3.37E+05		
Beryllium	4.02E+01		
1,3-butadiene	5.21E+04		
Cd	1.54E+02		
CCl_4	4.85E+02		
Chloroform	3.38E+03		
Cr	1.15E+03		141
Coke	1.44E+03		
1,3-Dichloropropene	2.14E+04		
Diesel	5.24E+05		
EDB	1.26E+01		
EDC	7.77E+02		
EtO	1.42E+03		
Formaldehyde	3.28E+05	11341	
Hexachlorobenzene	9.95E-01		
Hydrazine	2.75E+01		
MeCl	8.50E+04		
Ni	1.20E+03		930
Perc	4.39E+04		
PAH	8.72E+02		
Quinoline	1.48E+01		
1,1,2,2-Tetrachloroethane	1.24E+02		
TCE	2.57E+04		
VC	1.23E+03		
Total	1.56E+06	1.33E+04	1.13E+03
Percentage reduction in total emissions		0.85%	0.1%
Mortality risk reduction		4.E+00	4.E-01
Cancer incidence reduction [assuming incidence = 2(mortality)]		8.E+00	7.E-01
Mortality risk reduction (alternative calculation)		4.E+01	4.E+00
Cancer incidence reduction [assuming incidence = 2(mortality)]		8.E+01	7.E+00